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(54) A SELF-SUPPORTING ROOF OR ROOF SECTION

(71) We, EVERLITE A/S, a Company organized under the laws of Denmark, of DK-3320, Skævinge, Denmark, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a self-supporting roof or roof section of the type comprising a plurality of extruded plastics profile elements connected side-by-side, each element having at least one longitudinal chamber and coupling members at either side by which neighbouring profile elements are interconnected, the adjacent coupling members of neighbouring profile elements engaging to form a duct of oblong cross-section.

In the manufacture of the known roofs of this type a predetermined number of profile elements are assembled into a roof section at the works, the profile elements being interlocked by means of short rectangular locking members which are inserted into the ducts between neighbouring profile elements with regular mutual spacings, care being taken that the locking members in adjacent ducts are aligned for the sake of appearance when in due course the roof is to be viewed from the inside against the light. The shortness of the locking members ensure easy insertion without too great friction. The insertion of the locking members into their precise position is performed manually and must not be done in jerks but slidingly actuated by an expedient elongate tool in order to obtain alignment.

The assembled roof section is then placed on a table having a curved surface corresponding to the shape of the roof desired and is subjected to heat treatment so as to assume a curvature corresponding to that of the table. After cooling, the roof sections are stabilized in the desired curved shape and can be transported to a building site where they can be assembled into a complete roof of the desired extent. The roof sections are connected together like the profile elements by inserting short locking members into the ducts formed by engagement of the coupling members of neighbouring roof sections. These locking members must be carefully placed so as to be aligned with those already inserted at the works.

Architecturally, self-supporting roofs of this type are superior to a number of other roof types.

The fact is, however, that in competition with other roof constructions, such self-supporting roofs of non-plasticized plastics have been able to hold their own only within certain limited roof dimensions, since in the case of larger roof areas it has not been economically possible under all circumstances to satisfy the strength moduli required by the authorities with regard to factors, such as the load per square metre.

An increase in the thickness of material in the profile elements makes the roof more expensive and results in an increase in weight and transport costs, besides an increase in the consumption of raw material which bears no reasonable proportion to the increase in strength achieved.

It is an object of the invention to provide a roof of the aforesaid type which, while preserving its essential architectural form as a self-supporting roof, fulfils the requirements of the load carrying capacity.

The present invention consists in a self-supporting roof or roof section comprising a plurality of transparent extruded plastics profile elements connected side-by-side, each element having at least one longitudinal chamber and coupling members at opposed sides by which neighbouring elements are interconnected and which form substantially rectangular ducts of oblong cross-section in which are inserted longitudinally, elongate, plate-like locking members, the ends of the locking members being fastened to carriers and each having at least two opposite longitudinal edges that are a sliding fit within a

respective duct so as to prevent the locking member from twisting under load, and the locking members, the profile elements and the ducts being curved in the same circular-arc shape.

In spite of the fact that the plate-like locking members are limited by the dimensions of the ducts, and may therefore only be relatively thin, tests made at an officially recognized testing laboratory gave the surprising result that the load carrying capacity is increased by a factor of three or more. In addition, it is surprising that the insertion of the curved locking members, which have a length corresponding to the full span of the roof, into the narrow ducts is not difficult in spite of the fact that there must be a sufficiently close fit between the locking members and the walls of the ducts to ensure secure locking. When care is taken that the radii of curvature for the roof and for the locking member are identical, the size of the radii can be selected freely within a sufficiently wide range.

The increased transparency of the plastics used for the profile elements has lead to demands for increased accuracy in mounting the short plastics locking members in the known roofs. Further, even when mounted quite correctly they cause shadows or darker zones which upset the architectural impression. These problems are completely eliminated by the use of the locking member according to the invention which pass through the whole length of the ducts. In addition, a sun-screening effect is achieved by making the locking members of metal, these being located in vertical planes and functioning as sun-screen slats.

According to another aspect, the invention consists in a method of manufacturing the roof or roof section by placing the profile elements separately on a curved table for heat treatment by which they are given the curved shape which they preserve on cooling. It is, however, still possible to produce roof sections at the works, and the locking member can be inserted in one coupling member prior to assembly of two neighbouring profile elements, those subsequently being assembled by a relative longitudinal displacement of the two profile elements. As regards transportation, the construction also offers advantages, because it is stronger, and because the risk of a displacement of the short locking members of said known construction is eliminated.

The locking member may for example be composed of an aluminium alloy and may be extruded and later curved into a circular shape, e.g. by cold rolling. The locking member may fill up the duct only along the two longitudinal edges, but may also be provided with a central thickening which engages the wall of the duct along a line. By this means, proper support of the locking member is achieved, and if it abuts on the wall of the duct it is to some degree supported against being bent outwards.

The invention will now be explained in greater detail with reference to the accompanying schematic drawings in which

Figure 1 is a perspective view showing part of an embodiment of an extruded profile element for a self-supporting roof according to the invention,

Figure 2 is a perspective view showing part of an embodiment of an extruded locking member for a self-supporting roof according to the invention,

Figure 3 is a perspective view showing part of the connecting members on two neighbouring profile elements as in Figure 1 which together form a duct for a locking member,

Figure 4 a cross-section through an embodiment of a roof according to the invention comprising two neighbouring roof sections,

Figures 5—8 show four different embodiments of profile elements with more than one compartment seen from the end, and

Figure 9 is a perspective view of a detail of the lower part of the roof with fastening means for the locking members and a Z-shaped carrier welded to a support.

The embodiment, illustrated in Figure 1, of a profile element for a self-supporting roof according to the invention is extruded in a non-plasticized plastics, a so-called hard plastics. The length of the profile element depends on the span of the roof to be erected. The element is shown in this embodiment as a single-chamber element, but it may be a double-chamber or multi-chamber element as illustrated in Figures 5—8. Coupling means are provided, but not shown in Figures 5 and 6. The chamber in Figure 1 comprises two vertical side walls 1 and 2 and two substantially horizontal side walls 3 and 4. The side walls 3 and 4 are both shown having an outwardly directed curvature, but may of course also be straight or have an inwardly directed curvature so that their concave surfaces face outwardly. The chamber formed by the walls 1, 2, 3 and 4 may be divided into several longitudinal compartments or chambers by partitions as illustrated in the embodiments shown in Figures 7 and 8.

The vertical wall 1 in Figure 1 is extended upwardly and downwardly in relation to the chamber and at its top joins a horizontal outwardly projecting part 5 to form an L-shaped coupling member, and at its bottom joins a horizontal outwardly projecting part 6 carrying a vertical upwardly projecting part 7 to form a U-shaped coupling member. Correspondingly, the vertical side 2 comprises a vertical extension at its bottom which joins a horizontal outwardly projecting part 8 to form an L-shaped coupling member, with a vertical extension at its top joining a horizon-

tal outwardly projecting part 9 carrying a vertical downwardly projecting part 10 to form a U-shaped coupling member. Consequently, the profile element is point-symm t-rical around its central axis, or more correctly since the central axis is curved in the vertical plane, any cross-section perpendicular to the central axis shows central symmetry.

Figure 3 shows how two neighbouring elements of the type illustrated in Figure 1 are joined. The joining can be performed in two different ways, viz. either by the elements being slid into each other like rails by mutual axial displacement or by being inserted laterally, that is to say by two mutually perpendicular displacements transversely to the longitudinal direction. In either case, an L-shaped coupling member on one profile member fits within a U-shaped coupling member on an adjacent profile member.

In Figure 3, parts associated with the neighbouring element to the right are designated by the same reference numerals as parts shown to the left on the profile element in Figure 1, but with the addition of the letter *a*. It will appear that the side walls 2 and 1*a* as well as the bent-over parts 8, 9, 10 and 5*a*, 6*a* and 7*a* together form a channel or duct which is substantially rectangular in cross-section. In the known construction, short wedges of plastics are pushed into this duct and draw the parts 8 and 6*a* as well as 5*a* and 9 towards each other and thus prevent release of the two profile elements from each other except by displacement in the axial direction. The insertion of the wedges is done manually by means of long tools and requires a certain degree of skill because the wedges must be correctly positioned within the ducts to satisfy architectural conditions.

According to the present invention the wedges of plastics are substituted by an elongate, plate-like locking member 20, preferably of an aluminium alloy, which extends all the way through the duct and at its ends rests on and is secured to the supporting members of the roof structure.

Despite the fact that the locking member 20 shown in Figure 2 has a thickness of only a couple of millimetres, it considerably increases the strength of the structure, the load carrying capacity being increased by more than a factor of three. By way of example it may be mentioned that in the case of a maximum snow load there is a factor of safety of five to six. The locking member 20 shown in Figure 2 consists of an extruded aluminium alloy. Along the two opposed side edges, thickenings 21 and 22 are provided, so that the locking member fits with a slide fit into the duct in Figure 3. The locking member may have one or more strengthening ribs 23, and the ribs may be so high that they are supported against the walls of the duct.

The surprising strength of the structure may be explained by the fact that the plastics acts as a support for th locking members and keep them in the vertical plane even when under heavy load. The load carrying capacity can consequently be utilized to a particularly high degree. This theory is confirmed by the fact that load tests to the ultimate breaking stress show that in the case of overload a twisting of the locking members takes place.

An advantage of the self-supporting roofs dealt with here is that they can be manufactured of profile elements of translucent plastics which admits light. In spite of this advantage and a widespread wish to utilize this roof structure architecturally it has so far been necessary to limit its use to roofs of smaller proportions. The new construction increases the possibility to a wide extent.

At the same time the work of mounting the roof is reduced considerably since the accurate fitting work necessary for ensuring the relative location of the wedges of plastics can now be dispensed with. In addition it turns out that even a sun-screening may be achieved due to the presence of the aluminium locking members which act as slats preventing the direct passage of oblique sunrays. The slats may incidentally be utilized architecturally by the surfaces being given patterns or colours and possibly by perforations. In the latter case, regard must, if necessary, be paid to the fact that the load carrying capacity may change.

The extruded profile elements are cut into suitable lengths and are next subjected to a heat treatment, being supported on a curved support having the shape of a circular arc. The radius of curvature may e.g. be 4—6 metres.

The locking member is given a corresponding circular-arc shape, e.g. by cold rolling. It is necessary that the locking member and the profile elements have the same curvature. When this is the case, it will not be difficult to assemble the profile elements and insert the locking member into the duct. For the sake of simplicity, the curvature of the profile elements is not shown in Figure 3.

The fact that the locking members are now playing the part of carrying members while the profile elements may act only as lateral supports for the locking members, offers a greater freedom as regards the design of the profile elements, since they need only keep the plate-like locking members on edge under load.

It is still possible to assemble several profile elements at the works to form a suitably large roof section. The assembling expediently takes place by the elements being piled on top of each other, each being turned 90° around the longitudinal axis in relation to the position shown in Figure 1, that is to say they are made to lie on their sides on a plane support. Due to the presence of the locking members passing

through the elements, a roof section of this type is more stable and better suited for transport than the known combined elements in which the locally placed locking members of plastics might shift during transport and consequently may need readjustment at a later time.

The insertion of the locking members, the body of which has a thickness of less then 3 mm, gives no trouble either at the works or at the building site. Ordinarily, an extruded aluminium locking member will when leaving the works have lubricant residues which facilitate the insertion. If this should not be the case, lubricant may, of course, be applied.

In Figure 4 is shown in a schematical way two sections of a self-supporting roof according to the invention. Each of the roof sections is supported only along the lower parallel sides and there may be as many sections as wanted. A profile element in one section is denoted 40 and in the other 41 and they may be of the kind shown in Figure 1 with a circular curvature, for example with a radius of 5—6 meters. A number corresponding to the length of the roof, for example 100 metres, are interconnected for example as shown in Figure 3. In the ducts formed by interconnecting the roof elements or profile elements are inserted plate-like locking members for example of steel or an aluminium alloy the ends of which members rest on carriers 42 of an expedient cross-section corresponding to the shape and curvature of the roof elements. The carrier may be supported by beams 43 and/or pillars, not shown, or any other expedient construction. The locking members 45 may be secured to the carriers 47 by passing an anchoring member such as a bar or tube 44 through aligned holes in the locking members 45 and bolting the bars to the carriers for example by means of hook-formed bolts gripping with the hook 46 around the bar or tube 44 and fastened in holes in the carriers 47 as illustrated in Figure 9 in which the cross-section of the carrier 47 is shown Z-like. In this embodiment the carrier 47 is welded to a support 48 of a suitable length which thus forms part of the carrier.

Figures 5—8 only show cross-sections of the profile elements made of plastics, e.g. pvc. Locking members may be inserted in the ducts 50 and 51 in Figure 5 and 60 and 61 in Figure 6, although these ducts are not established by interconnecting coupling members but are parts of the extruded profile. Thus said locking member acts only as a carrying member when inserted in these ducts.

WHAT WE CLAIM IS:—

1. A self-supporting roof or roof section comprising a plurality of transparent extruded plastics profile elements connected side-by-side, each elem nt having at least one longitudinal chamber and coupling members at opposed sides by which neighbouring elements are interconnected and which form substantially rectangular ducts of blong cross-section in which are inserted longitudinally, elongate, plate-like locking members, the ends of the locking members being fastened to carriers and each having at least two opposite longitudinal edges that are a sliding fit within a respective duct so as to prevent the locking member from twisting under load, and the locking members, the profile elements and the ducts being curved in the same circular-arc shape.

2. A self-supporting roof as claimed in Claim 1 in which the plate-like body of each locking member has a thickness of less than three millimeters and consists of metal.

3. A self-supporting roof as claimed in Claim 1 or 2, wherein the coupling members are U-shaped and L-shaped, an L-shaped coupling member on one profile element fitting within a U-shaped coupling member on an adjacent profile element.

4. A self-supporting roof as claimed in any one of Claims 1 to 3 in which the locking members at each end are interconnected by an anchoring member which passes through aligned holes in the locking members and is fastened to a carrier.

5. A self-supporting roof as claimed in any one of Claims 1 to 4 in which the locking members are composed of an aluminium alloy, and rest on and are fastened to carriers which have a cross-section of substantially Z-form and which are welded to an elongated supporting plate.

6. A method for use in the manufacturing of a self-supporting roof or roof section composed of profile elements and locking members as claimed in any one of Claims 1 to 5, in which, prior to assembling the profile elements, said elements are bent in the shape of circular arcs, and the locking members are shaped into the corresponding form of circular arcs, after which assembly takes place.

7. A method as claimed in Claim 6, in which a locking member is inserted into its place in the coupling members of one profile element, after which a second profile element is slid in over the first element by a longitudinal mutual displacement so as to form said duct and enclose the locking member.

8. A self-supporting roof substantially as herein described with reference to the accompanying drawings.

9. A method of manufacturing a self-supporting roof or roof section substantially as herein described with reference to the accompanying drawings.

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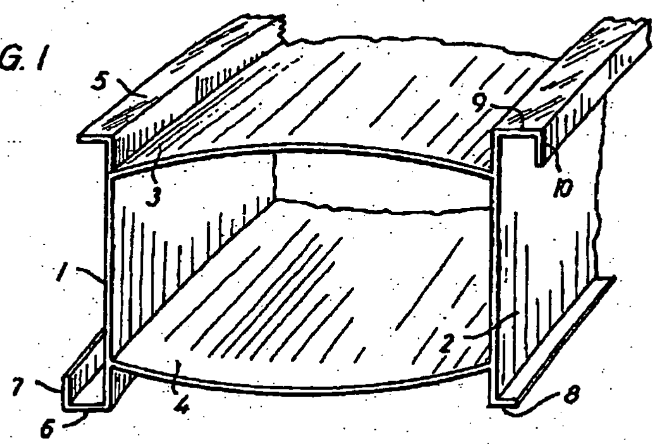
Sheet 1

FIG. 1



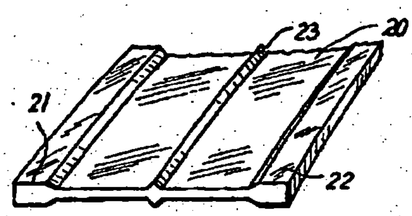


FIG. 2

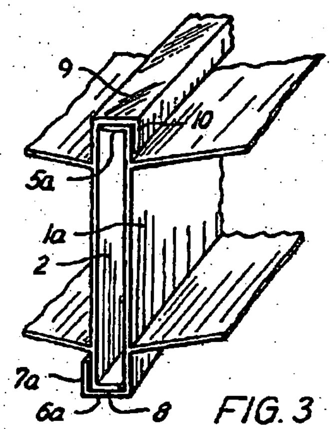
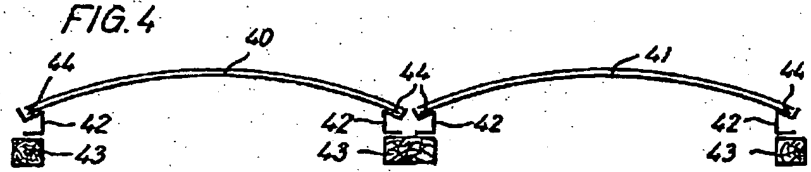


FIG. 3

FIG. 4



1528874 COMPLETE SPECIFICATION
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Sheet 2

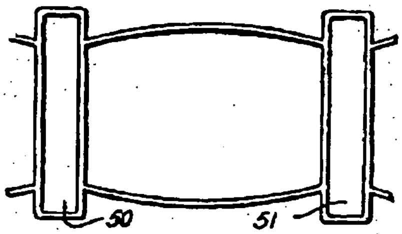

FIG.5

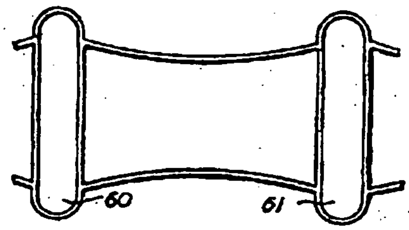

FIG.6

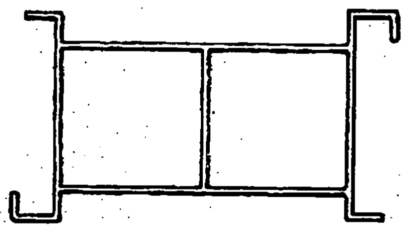

FIG. 7

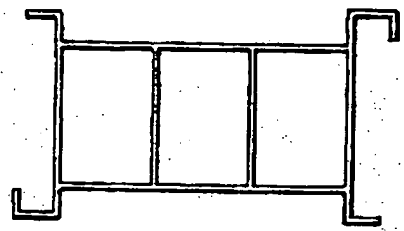

FIG. 8

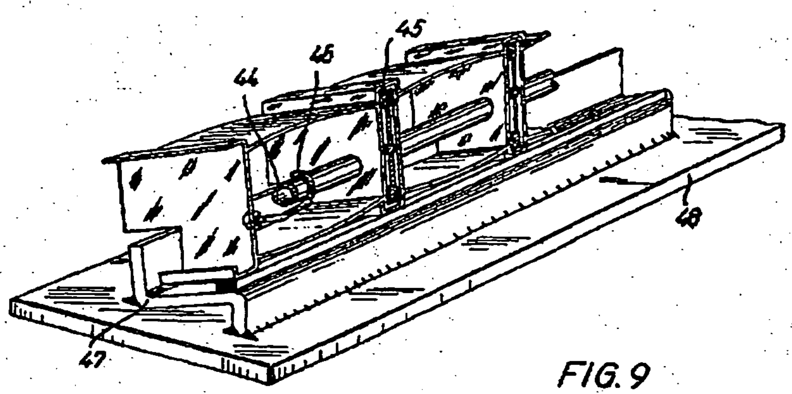

FIG. 9